THE EFFECTS OF BILATERAL OVARIOTOMY IN THE BROWN LEGHORN FOWL.[1]

L. V. DOMM,

Whitman Laboratory of Experimental Zoölogy,

The University of Chicago.

Two plates (4 figures).

Introduction.

In a previous report (Domm, '27*a*) the effects of complete ovariotomy were recorded in detail. It was shown that following the total ablation of the normal left ovary in the brown Leghorn fowl the right gonad, which normally is a minute rudiment, hypertrophies and forms an organ usually of testis-like form and structure. In these earlier cases, where the operation was performed at a relatively late age, these testis-like right gonads were always sterile. In a subsequent series (Domm, '28, '29), in which the operations were performed at a very early age, some of the hypertrophied testis-like right gonads thus far examined reveal active spermatogenesis, though in other respects, relating principally to secondary sexual characters, these individuals are essentially similar to those described in our earlier series (Domm, '27*a*). The rudimentary wolffian ducts respond to the presence of these testis-like gonads by growth and often by coiling. The left oviduct, in the absence of the ovary, shows varying degrees of reduction. Such birds develop the secondary sexual characters of the male. Hence the plain female plumage is gradually replaced by the more gaudy male plumage (see bird no. 1018, Plate 1) but this is subsequently replaced by henny plumage when the testis-like gonads attain sufficient activity (see bird no. 845, Plate 1). The head furnishings usually relatively small and fine in texture after a time, varying somewhat in different individuals, become large,

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coarse, and male-like (see Plate 1). Spurs develop and attain varying dimensions (see Plate 1). Behavior is likewise modified. The normal female is comparatively peaceable. Following the operation many of them eventually become pugnacious, acquire an interest in the female, crow, and attempt to tread.

The experiments on castration and those on transplantation of male gonads in the cock (Domm, '27*c*, and others) have shown that the testes have a pronounced effect on the development of the dependent sex characters. Hence in the presence of the male gonad the dependent characters, including head furnishings, behavior, and to a lesser degree the sexual ducts, are well developed while in the absence of the male gonad they become reduced and inconspicuous or disappear (for type of head furnishings in capon see bird no. 608, Plate 2). The development of certain male characters in the poulard, such as masculine head furnishings, behavior, and growth of the wolffian ducts was therefore attributed to the presence of the testis-like compensatory gonad found on the right, or a similar gonad occasionally regenerated on the site of the removed left ovary (Domm, '27*a*). In order to verify this supposition it was essential to remove these gonads and observe the effects on these characters.

Benoit ('23) performed an operation of this type on a white Leghorn female when approximately 6 months old. This bird had been previously ovariotomized at the age of 26 days. Whether this operation was completely successful in removing all gonad tissue beyond the possibility of subsequent regeneration is not known, as the bird was not kept a sufficient length of time, though from our experience we would surmise the contrary. Zawadowsky ('26) likewise reports a case in which he endeavored to remove the right testis-like gonad. The ovary had been previously removed on November 15, 1919 (age not given), and on May 18, 1922, approximately 2½ years later, the bird was opened on the right and the oval testis-like gonad incompletely removed.

In our earlier series of ovariotomy experiments (Domm, '27*a*) attempts were made to remove some of the hypertrophied right gonads by secondary operations. However, removal of the gonad at this late stage in its development was found to be difficult and exceedingly hazardous owing to its firm consistency and its posi-

tion over, and close adherence to the large post caval and right iliac veins. These gonads are never attached by a narrow mesorchium, as is the normal testis, but they invariably show a more diffuse area of attachment rendering their extirpation extremely hazardous. A considerable number of extirpations of the fully formed gonad were attempted. However only a few of these attempts were completely successful in the sense that no regeneration of the gonad had subsequently occurred as witnessed by post-mortem examination.

The hazards involved in completely disposing of all gonad tissue once the organ has fully hypertrophied, allied with its subsequent regeneration and growth, made its advisable to perform this operation at a much earlier age before the right rudimentary gonad had shown any appreciable hypertrophy. In the normal female fowl the rudimentary right gonad consists merely of a long, narrow, flattened sheet of tissue extending posteriorly from the median border of the right adrenal on the vena cava and junction of the right iliac veins. Following ovariotomy its growth is usually negligible macroscopically prior to the third week. Attempts to remove it surgically in this state would essentially be equivalent to an attempt to remove a part of the wall of the post caval itself. A new technique was therefore devised by which the rudimentary gonad was destroyed prior to hypertrophy by means of a small electric cautery. This method differs from that previously employed only in the destruction of the gonad at an early stage by cautery rather than its much more hazardous surgical removal at a later stage. This method has several obvious advantages. It enables one to perform the operation anytime prior to, or shortly following, ovariotomy. The operation also has the pronounced advantage of being much less hazardous for with moderate care one may completely destroy the rudimentary gonad with no, or very little, hemorrhage, a state of affairs practically impossible with the former method. Furthermore, any small part of the gonad not destroyed by the initial operation may readily be destroyed by a subsequent cauterization.

This investigation is part of a larger program on the biology of sex now being pursued at this laboratory under the direction of Prof. Frank R. Lillie. Acknowledgments are due Prof. Lillie for his assistance in making this study possible.

Experiments.

Thirty birds of the same age and approximately the same size were selected for this experiment. These were ovariotomized late in the summer and early fall of 1926 at ages ranging from 76–79 days. Each of these birds was subsequently opened on the right side between 16 and 22 days following the initial operation (see table) and the rudimentary gonad destroyed by thoroughly searing with a small electric cautery. Nineteen of the birds thus operated form the basis for this report while the findings in the rest of the series will be recorded at a later time. No difficulty was encountered during the course of this new method of operation. With very few exceptions the operation was completed with no, or very minor, hemorrhage and in most instances the bird was in good condition and recovered rapidly following the operation. In a few cases where recovery was slow the difficulty could be traced to the initial, more severe, sinistral operation.

Results.

In the experiments forming the basis for the present report the birds were deprived of both right and left gonads practically simultaneously; hence no dependent male characters ever developed. The changes observed following these operations coincide more closely, in some respects, with those *immediately* following sinistral ovariotomy than with those observed where the secondary dextral ovariotomy is performed at a much later time when the bird had assumed masculine characters. In the latter case there is usually a rapid decrease or disappearance of the dependent male sex characters, such as head furnishings and behavior, associated with a reversion to male plumage if the bird had assumed female plumage prior to the operation (Domm, '27*a*). A general categorical description of the effects of these operations will be given. All individual cases can obviously not be described in detail hence the description given in the text will be of a general nature with frequent reference to the tables to which the reader is referred for detailed case histories. For details on methods of operation, records, and preservation of materials the reader is referred to an earlier paper (Domm, '27*a*).

Effect on Head Furnishings.—The birds selected for these operations were relatively young growing pullets whose head furnishings at the time of operation were juvenile and had not yet attained very prominent proportions. The head furnishings therefore did not show a reduction in size as is frequently the case in the pullet ovariotomized at a later age when these characters have become relatively prominent. In a few instances where these characters were conspicuously red at the time of operation they became noticeably pale subsequently. In the completely successful cases these characters showed a slight gradual increase in size corresponding, in all probability, to the general increase in body size of the growing bird, until the bird matured, following which there is but little fluctuation in size (see table, cases no. 875, 876, 882, 884, 895, 897, etc.). Hence such a mature female completely deprived of all gonad tissue shows small, usually pale, comb, wattles, and earlobes (see bird no. 876, Plate 2).

In a number of cases the head furnishings later became red and turgid and manifested signs of growth though the size attained varied in each instance (see table, cases no. 874, 878, 880, 893, etc.). It is interesting to note that in each of these cases this growth was subsequently followed by a marked decrease. In a few cases this decrease was probably due to the general condition of the bird as it will be noted by reference to the table that a number of these birds died. In a few of the cases it may justly be attributed to this cause as the birds were sick for some time prior to the time of death (see table, cases no. 874 and 878). However one of the birds died because of crop-binding in which case it was afflicted for but a short period and when killed showed no symptoms of organic disease (see table, case no. 898). A few of these lived to the termination of the experiment and were killed in good condition (see table cases no. 880 and 893). Hence this reduction in size of head furnishings is not attributable in all cases to the poor physiological condition of the bird, though this is very frequently the case (see Domm, 27*a*), but must be imputable to other causes.

It will be noted by reference to the table that each of the cases showing conspicuous growth of head furnishings also reveals varying amounts of testis-like gonad. It is significant that such

birds may show the small capon-type head furnishings for practically 1½ years and subsequently show pronounced development of head furnishings indicating regenerating gonad (see table, case no. 894). This bird, whose complete history is given in the appended table, showed small capon-type head furnishings for 18 months following the operation, indicating a successful operation, which later became red, turgid, and conspicuously prominent. Bird no. 890 is exceptional and warrants mention in this particular. The head furnishings of this bird showed conspicuous growth between the 5th and 8th months following the operation (see table) after which there was a slight decrease. Post-mortem examination revealed no gonad tissue on either gonad site indicating successful removal. It is very probable that the growth observed here was due to an accidental autoplastic ovary graft which was being resorbed when the head furnishings began to decrease hence it could not be found at the autopsy.

Effect on Plumage.—The general differences in plumage exhibited by the sexes of the domestic fowl are fairly well known. For details of the plumage dimorphism, which is very pronounced in the light brown Leghorn, the reader is referred to an earlier paper by the writer (Domm, '27*a*).

The birds used in the present experiment had assumed the early female plumage at the time of operation. Following the operation they developed the juvenile plumage of the male to varying degrees (see table). These feathers are particularly conspicuous on the back, saddle, and wing areas. The new feathers on the breast and laterally, while juvenile for a time after the operation, early became black as in the mature male. This precocious development of definitive male feathers in these areas coincides with their earlier development in these regions in the male. However new juvenile feathers did not appear indefinitely in any region of the body for by 4 to 6 weeks after the operation the new ingrowing feathers were of the definitive male type in all areas. Mention should perhaps be made of the fact that the juvenile plumage is not lost as soon as adult plumage begins to appear but that this is usually a very gradual process, hence the presence of juvenile plumage at 6 months after the operation as the table reveals in a number of cases. Unfortunately the table does not give changes

between 6 and 12 months, if it did it would reveal the fact that some of these individuals retain this type of plumage even longer than 6 months. In exceptional cases where birds are in poor physiological condition and fail to mature before the onset of cold autumn weather these feathers may be retained until the following spring. By two to three months after the operation most of the birds in the experiment presented a conspicuous plumage consisting of some scattered old female feathers, a few scattered feathers showing female tips and male bases, particularly conspicuous on the breast and lateral areas, numerous juvenile feathers conspicuously confined to the back, saddle, and wing areas, and many adult male feathers most abundant on the breast and laterally but not by any means inconspicuous in all other areas. By five to six months after the operation the plumage had become completely male in all areas with some scattered juvenile feathers on the back, saddle, and wing areas in some cases (see table). If the operation is completely successful such a bird develops and retains (in these cases approximately 2½ years) a brilliant, luxuriant, adult male plumage (see table cases no. 875, 876, 882, 884, etc.), showing no subsequent reversion to female plumage as does the female in which merely the functional left ovary has been removed (see bird no. 845, Plate 1, also Domm, '*27a*). The successful bilaterally ovariotomized female therefore approximates the castrated male in this particular (compare birds nos. 876 and 608, Plate 2).

In several cases (see table, birds no. 880, 891, 893, 894) the bird developed male plumage for a time following the operation and later reverted to female plumage. Reference to the table will reveal that in each of these cases this reversion in plumage was preceded by considerable increase in the size of the head furnishings which in turn disclosed the presence of regenerating gonad. Bird no. 891 revealed such a reversion in plumage following considerable increase in size of head furnishings. Later these again decreased in size following which the new plumage again became male in character. About this time (October 16, 1927) a dextral laparotomy was performed, revealing a small mass of right gonad which was thoroughly seared. During the following 16 months to the time the bird was killed (March 1, 1929) the plumage remained male in character and the head furnishings small and

capon-like. Post-mortem examination revealed no gonad on either right or left sides. In bird no. 880 there was likewise a reversion in plumage to the female type following considerable growth of head furnishings followed by a reversion back to male after these characters had regressed for a time. Birds no. 893 and 894 showed a similar reversion to female plumage, though at widely different intervals, but differed from the above in that they did not revert back to male again but they probably would have done so given sufficient time correlated with no gonad activity as evinced by decrease in head furnishings.[1] Birds no. 874, 878, and 898 developed and retained male plumage to the time of death. In each post-mortem examination revealed some gonad (see table) correlated with growth of head furnishings which was most pronounced, though of short duration, in bird no. 898 and negligible in each of the others.

Effect on Spurs.—The effects of castration on the spurs of the male are incompletely understood. The Leghorn capon in our experiments always has well developed spurs (see bird no. 608, Plate 2). They however do not seem to grow any longer than those of the normal cock. The only appreciable difference we have been able to observe concerns their development. The spurs of the capon become sharp and pointed early in their development while those of the normal male remain stout and blunt for a considerable period, sometimes well into the second year.

The normal female of the Leghorn breed usually lacks spurs

[1] The gonadal plumage relationship in the poulard is evidently explicable on a quantitative basis. In the absence of gonad the female develops and maintains cocky plumage; the presence of small amounts of regenerating gonad does not alter this condition. As the mass of regenerating gonad gradually increases in size and presumably also in hormone production it eventually attains the point where it partially inhibits male plumage, and intermediate plumage develops. If the volume of hormone produced becomes still greater it ultimately attains the point where it completely inhibits male plumage and female plumage develops. This is to be explained by a secondary gradual development of female hormone as will be described in other studies by Domm and Gray. The parallel regression of head furnishings and secondary reversion of plumage from female to male in the cases described above indicate that the hormone production of the compensatory gonads was not much above the threshoid of effectiveness and was readily depressed below it by sickness or lowering of vitality of the bird. The same principle was found to apply in our cases of sinistrally ovariotomized birds previously described (Domm, '27*a*).

though cases are known where otherwise normal females showed well developed spurs (cf. Domm, '27*a*, p. 86, also Goodale, '16). The young pullet of our breed shows no spurs, though one may always identify the small, oval, imbedded, spur rudiment on the inner surface of the shank. These rudiments gradually become more conspicuous throughout the life of the fowl though in no instance have we observed them more than a few millimeters in length in the old spurless hen.

Following sinistral ovariotomy in the Leghorn spurs have developed in all cases without exception (see birds no. 1018 and 845, Plate 1). The rate of growth and the ultimate size attained varies somewhat in individual cases though relatively well developed spurs are nevertheless the rule in all such birds. The development of spurs in the bilaterally ovariotomized birds of this series differed in no important respect from those in which merely the left ovary had been removed (see bird no. 876, Plate 2). Individual differences occur though the size attained in individuals of comparable age is apparently no greater in the one group than in the other. The table gives the length of the spurs in centimeters at the time of autopsy. For data on spur growth following sinistral ovariotomy the reader is referred to a previous publication (Domm, '27*a*).

It was pointed out above that the spurs of the capon become sharp and pointed earlier than those of the normal cock. Indications are that the spurs of the sexless female may not become pointed as early as those of the capon in at least certain individuals. Birds no 902 and 903 (see table) show spurs at 9½ and 8½ months following operation which are well rounded and blunt at the ends. On the contrary bird no. 878 (see table) shows sharp pointed spurs at 10 months. All individuals sacrificed toward the termination of the experiment had well pointed sharp spurs though the actual length attained varied considerably.

Effect on Voice and Behavior.—It is generally conceded that the normal female does not tread, that she is less combative than the male and that she does not crow. It is likewise held by many that the capon does not tread nor crow and that he is inclined to be non-combatitive. Following sinistral ovariotomy the female may develop the behavior of the male to a striking degree (see Domm,

'27*a*). Such a bird will crow, fight the male, call the female to an alleged morsel of food and attempt to tread but, while these reactions are very common and characteristic, instances where such a bird will actually tread are apparently very exceptional. It was previously pointed out (Domm, '27*a*) that when such an ovariotomized fowl is later completely castrated she loses her masculine voice and behavior and becomes capon-like.

In the present experiments the birds were bilaterally ovariotomized at a relatively early age. In cases where this experiment was completely successful, in disposing of all gonad tissue so that none regenerated subsequently, the bird never developed or exhibited the masculine voice or behavior. Such a bird develops much as does the capon in this respect. They were found to be relatively inactive and non-combatitive. They are noticeably more quiet than the normals of either sex. It was further observed that they will not receive or interest themselves in the male but are rather inclined to avoid him. They were never observed to brood, neither did they build nor sit on the nest nor did they appear to interest themselves in chicks; however the broody instinct has practically been lost in the variety of brown Leghorn with which we are here concerned. The broody instinct has been manifested in but a few cases in our flock of normal hens and communication with fanciers on this point indicates that this instinct is nearly lost in certain varieties of Leghorns at least. Hence this reaction is probably not to be expected in the sexless females in this experiment. Birds in which the operation has been incomplete as witnessed by the presence of regenerating gonad of testis type exhibited degrees of masculine behavior no different from that found in the sinistrally ovariotomized fowl.

Effect on size.—The size differences between the sexes of most breeds of fowl are well recognized. The Leghorn breed does not appear to be exceptional for here the male is conspicuously larger than the female. The stance in the two sexes also differs. The cock is characterized by a noticeable upright stance while that of the female is more horizontal. It is quite generally conceded that the male fowl when castrated, at a relatively early age, grows larger than the normal. The normal Leghorn capon in our flock has grown somewhat heavier than the normal cock but whether this is

due to excessive accumulation of fat, for which the capon is renowned probably due to his lethargy, or to an actual increase in skeletal proportions we have as yet not established. The probabilities however are that both factors are involved. Following castration the stance of the cock is altered, becoming horizontal so that it approximates more nearly that of the female.

No actual measurements have been made to show whether the fowl shows any changes in size of skeleton following sinistral ovariotomy. The general impression is that the poulard is no larger than the normal hen. Goodale ('16) contends that the poulard probably does not exceed very appreciably, if any, the size of the normal hen. He admits that his data have not been of sufficient extent, nor his stock sufficiently homogeneous in respect to weight, to give results of value. Finlay ('25) states that the ovariotomized female (sinistral) retains the skeletal characters and body shape of normal females but gives no measurements to substantiate his contention. We have found exceptional cases (Domm, *'27a,* also unpublished data) where the poulard was noticeably larger though in general we are inclined to believe that such size changes, while they may occur, are in most instances negligible. Furthermore since sinistral ovariotomy in the fowl does not produce a gonadless bird, as was formerly supposed, it is perhaps not to be expected that she would change appreciably in size if at all.

Size differences in the bilaterally ovariotomized Leghorn in our experiments deviating from the normal are not very conspicuous if they occur at all. In fact we are inclined to believe that they do not change in size or, if they do changes certainly are not as obvious as they appear to be in the capon. As concerns weight we find that many of our sinistrally ovariotomized females exceed the weight of the sexless bilaterally ovariotomized birds in this experiment. The average weight of the normal female when one year old is approximately 1400 grams. This weight is not exceeded by the sexless females of this series. The age at the time of operation in these experiments coincides with that at which castration is usually performed in the young male following which there is generally an increase in size. The statements made here are based on general observations and the weights of the birds. No further

commitment can be made until further data are available on this question to be gathered from preparations now being made.

Effect on Accessory Organs.—The term accessory organs is here employed in its customary significance, namely the ducts that convey the products of the gonads to the exterior, the vasa deferentia and the oviducts. In the normal mature male the vasa deferentia are prominent convoluted ducts having a perceptible diameter. Following castration the convolutions are lost accompanied by a marked reduction in size so that one sometimes experiences difficulty in finding these small straight ducts in the adult capon. We have never found any indication of oviducts in the mature Leghorn male. The normal female has but one functional oviduct that on the left side. The right oviduct, present in early embryonic life, degenerates leaving a small rudiment, varying in size in different individuals, attached to the side of the cloaca. The wolffian ducts persist as small slender threads in the normal female. Following ablation of the left ovary the wolffian ducts hypertrophy and frequently become convoluted under the stimulus of the hypertrophying testis-like right gonad (Domm, '27*a*). The oviduct in such cases shows varying degrees of reduction though it is rarely entirely infantile. The highly glandular nature of the oviduct in a certain number of cases of complete sinistral ovariotomy indicates that it is receiving a stimulus in such cases comparable to that furnished by the normal left ovary.

The disposition of the accessory organs in the bilaterally ovariotomized fowl may differ greatly from that found in those merely sinistrally ovariotomized. If the bilateral operation was completely successful in removing all gonad tissue it was found that the wolffian ducts remained small and rudimentary comparable to those found in the normal female (see table, cases no. 875, 876, 882, 887, etc.). The stimulus furnished by very small masses of gonad is apparently insufficient to provoke growth changes as disclosed by case no. 878 (see table). In cases where the mass of regenerated gonad is of considerable size the wolffian ducts have responded to the stimulus furnished by considerable increase in size (see table cases no. 880 and 898). Such a result was to be expected on the basis of the writers earlier observations (Domm, '27*a*). A definite correlation between the amount of hyper-

trophied testis-like gonad present and the growth of these ducts would be difficult to establish though there can be no question as to its existence.

In all cases showing a total absence of gonad the oviduct consists of a small straight flattened tube having a diameter of only 2 to 3 millimeters (see table, cases no. 875, 876, 882, 884, etc.). Even in cases showing small masses of regenerated gonad the oviducts are small and straight and approximate the above in size (see table, cases no. 874, 878, 880, etc.). In only 3 of the cases included in this report were the oviducts other than exceedingly small (see table, cases no. 890, 893, and 894). In each of these cases the oviducts were convoluted and showed a diameter of 4 to 6 millimeters. It should be indicated that in each of the above three cases there is a definite correlation between stimulation of oviduct and reversion to female plumage. In cases no. 878, 884, 887, 899, and 902 (see table), different parts of the oviduct were inflated, to varying degrees, with a clear watery fluid. This condition is not uncommon in our ovariotomized birds and is probably associated with the atrophy of the oviduct in conjunction with the obstruction of both openings thereby preventing the escape of secreted fluids. Our practice of resecting all or a large part of the infundibulum prior to sinistral ovariotomy is no doubt responsible for sealing this end of the oviduct. Rudiments of the right oviduct were found in all cases attached to the side of the cloaca. These rudiments are very small in all of the cases belonging to this series though whether they show a greater reduction in these birds than they do in the normal or the sinistrally ovariotomized fowl would be difficult to estimate. In both our series of sinistrally ovariotomized fowl (Domm, '*27a*, and '28) we encountered many right rudimentary oviducts that were larger than the ones found in the present series but because of the great variation revealed by these structures this is probably not very significant.

Discussion.

The gonadless male and female of the Leghorn variety have a great many points of similarity. In both types the head furnishings remain small and pale and fluctuate little, if any, in size. Both types develop a brilliant, luxuriant, male plumage. The capon

develops long spurs which become sharp and pointed early in their development. The spurs of the gonadless female likewise become long though it appears that they become sharp and pointed somewhat later than those of the capon. The behavior of both types is neutral, neither exhibits the behavior of the normals of either sex. The wolffian ducts, which in the normal male are prominent and convoluted, become very small and straight in the capon so that it is frequently difficult to find them. These ducts are likewise very small and straight in the gonadless female and frequently very difficult to demonstrate. Her oviduct is also greatly reduced to a straight slender tube. The only apparent difference between these two types is that of size. The normal male of the Leghorn variety is larger than the female. Following early castration the male increases somewhat in size as compared with the normal. It is questionable whether the female, bilaterally ovariotomized at a corresponding age, increases in size above the normal. Hence the normal size differences between the sexes appear to persist and may even become somewhat aggravated owing to the increase in size of the capon above the normal male. Studies are now in progress to determine skeletal changes in the castrates of this breed.

The earlier experiments of the writer (Domm, '27*a*) and others have revealed the striking capacity of the female to assume male characters both in anatomy and behavior. These investigations have further shown that the female fowl possesses tissues in the hypertrophied right gonad, which are similar in their effects to the endocrine cells of the testes, upon which this transformation in large measure depends. The experiments of Goodale ('16) Zawadowsky ('22) Finlay ('25) and of ourselves (Domm, '28) reveal the fact that the male may undergo a corresponding transformation of male into female only by operative interference. Hence by grafting ovary into the castrated male such an individual may assume the plumage and head furnishings of the female. The present experiments further reveal the striking identity of the gonadless bird whether originally male or female. The results of castration thus lead to a type common to both sexes designated as the asexual or neutral type by various authors. Lipschutz ('24) maintains that during embryonic life the soma in birds is asexual,

and that the development of male and female characters takes place only under the influence of the sex specific hormones produced by the gonads. Zawadowsky ('22) on the basis of extensive work in the bird concludes that the soma of the male and female is essentially identical, and that differentiation is brought about only by the stimulus of sex specific hormones. He asserts that removal of the gonads leads to an asexual type hence the soma of either sex is "equipotential." Zawadowsky ('26) further reminds us that the development of the right rudimentary gonad in poulardes brings forth a morphogenetic reaction which is an indication of the bisexual nature of the hen. He maintains that not only is the somatic body potentially bisexual but that the left ovary and the right rudimentary gonad of the hen can both produce both male and female morphohormones presumably under given conditions. Furthermore these gonads may produce a typical testicular structure, with active spermatogenesis not infrequently occurring in the activated right gonad (cf. Benoit, '23, Zawadowsky, '26, Domm, '29). Hence Zawadowsky's theory of equipotency would include not only the somatic tissues but also the gonads and presumably the germ cells. Crew ('23) infact postulates equipotency of the primordial germ cells of both sexes. Greenwood's and Crew's ('25) assertion of a difference in intensity, or quantative difference, in male and female hormone and not a sex specific or qualitative difference as is postulated by Lillie ('27), Lipschutz ('24), Zawadowsky ('22 and '26) and others would in addition imply equipotentiality of the hormone secreting cells.

According to Lillie ('27) the real issue is, "what tissues of the male and of the female react equally to the two hormones, whether with respect to growth or alternate potentialities?" Our earlier experiments (Domm, '27*a*) and those of others have shown that in the female fowl the head furnishings, feathers, spurs, wolffian ducts, and to a certain degree the behavior, permanently retain the capacity to react to the male hormone as the corresponding characters of the male normally do. Feminization experiments by ourselves, and others, reveal a similar double potentiality on the part of the corresponding characters of the male. The above observations thus seem to show that the somatic tissues may react equally in both sexes to either male or female hormone while

Crew would include germ cells and Zawadowsky gonads and germ cells also. However as regards equipotency of gonad tissues the theory can apply only to the female and not to the male since no one has ever observed male gonad give rise to ovarian cortex in birds, or mammals for that matter, in spite of the numerous castration and transplantation experiments that have been performed.

If we accept the doctrine of equipotency in its fullest meaning as implied by Zawadowsky, Lipschutz, and others, should we then expect complete sex reversal in cases where the hormone is present in early embryonic life prior to the onset of sexual differentiation? If this is implied these authors would ignore the efficacy of the genetic sexual constitution as factors of differentiation for all extragonadal characters in the presence of the hormones. The observations of Lillie ('17 and '23) on the free-martin reveal a situation in which the production of the sex hormone for the male is demonstrated from the earliest period of sex differentiation. Lillie examined a case of a free-martin in which fusion of the membranes, according to his reconstruction of the probable history of this case, was possibly complete at least at the 10 mm. stage and a vascular anastomosis must have been established at the same time. Such a case, according to Lillie, would seem to have afforded the maximum opportunity of masculinization by the hormones of the male partner on account of the early time of onset and the long duration of possible action. However the modification of the free-martin in this case was not particularly extreme. Lillie ('23) says: "If there were no other factors at work in determining the sex differentiation of embryonic primordia than the specific sex hormone, it is difficult to understand why the free-martin, which receives only male sex hormones, should not become completely male." The chick embryo seemed to offer suitable material for a demonstration of the action of sex hormones on relatively early stages of the developing embryo. Minoura ('21) grafted gonad onto the chorio-allantoic membrane of developing chick embryos. His results seemed to show a definite modification of the female reproductive system in the male direction under the influence of an engrafted testis. Subsequent experiments by Greenwood ('25) Willier ('27) and Willier and Yuh ('28) would seem to show that gonad grafts on the chorio-allantoic membrane

do not exert a specific effect on the reproductive system of the host embryo as maintained by Minoura. The criticism that these grafts had to be made in the second week of incubation when sexual differentiation had already begun is perhaps not very weighty.

Present experiments do not justify the conclusion that sex hormones are absent or are not involved in sexual differentiation in the chick embryo; yet observations on the action of sex hormones in the fowl after hatching make it difficult to accept such a conclusion. Our present evidence on the participation of sex hormones in the development of sexual characters is in evident conflict. The observations of Lillie ('17) on the free-martin, those of Burns ('25) and Witschi ('27) on parabiotic twins in amphibia, and those of Burns ('27) on the effects of gonad grafts in amphian larvæ, furnish evidence for the participation of sex hormones in the embryonic development of sexual characters. On the contrary the observations of Greenwood ('25), Kemp ('25 and '27), Willier ('27), and Willier and Yuh ('28), on gonad grafts in the chick embryo, as well as those of Humphrey ('27) and Witschi ('27) on gonad grafts in amphibian larvæ, furnish negative evidence.

The theory of equipotentiality should receive a more rigorous test than it has hitherto received. There is no question of an apparently equal reaction capacity in males and females of feather germs, head furnishings, spurs, in short all the more obvious external secondary sex characters, to the presence of ovary or testis. The same thing may be true of the sexual ducts though the evidence is less conclusive; there is also evidence that sex behavior is strongly influenced by the heterologous sex hormones in the parallel direction. However the most interesting and fundamental question suggested by this work is whether the earliest lines of germ cells are also equipotential and capable of forming ova or spermatozoa according to internal environmental conditions. Benoit's ('23) implication is that they are not equipotential. He explains his cases of sex transformation in the female by assuming the presence of two distinct germ lines in the female, the male line, in the medulla of the ovary, and the female line, in the cortex "the one as rigorously fixed as the other from the point of view

of their cyto-sexual determinism." Our recent experiments (Domm, '29) have confirmed the occurrence of spermatogenesis following ovariotomy in the fowl and explained the causes of its occurrence. It seems to us more reasonable to believe that the primordial germ cells, of the female at least, are equipotential, and that their ultimate fate as male or female is determined by environmental exigencies; hence, when they become incorporated in the cords of the medulla they produce spermatogenesis and when in the cortical elements of the gonad they produce ovogenesis. This agrees with Witschi's ('29) interpretation of sex reversal in female tadpoles following the application of high temperature.

Are the endocrine cells of the gonad also equipotential and thus capable of producing male or female secretions according to environmental exigencies? Our present indications are that these cells are of two kinds, the male secreting and the female secreting. The female possesses both, the male secreting cells in a reserve of specific tissue the medulla, normally inhibited by the cortex, but capable of growth and secretion when this inhibition is removed (Domm, '27*a*, '28, '29), and the female secreting cells in the cortical elements of the gonad. The male possesses but one the male secreting cells. Our experimental results (Domm, '27*a* and unpublished data) demonstrate quite clearly that male hormone may be produced either by testis or ovarian medulla but that female hormone is produced only by ovarian cortex. There is therefore no indication of equipotentiality of these cells and according to Lillie ('27) "none is to be expected, seeing that these cells are the source of the postulated inductions of the double potentialities."

Summary.

1. Complete bilateral ovariotomy in the brown leghorn fowl leads to an asexual or neutral type common to both sexes in many of its characters.

2. The head furnishings which become large and male-like following sinistral ovariotomy remained small and fluctuated little in size following complete bilateral ovariotomy.

3. Following sinistral ovariotomy the plumage becomes male but at a later period, varying greatly in different individuals, it reverts to the female type. In our cases of complete bilateral ovariotomy

the plumage became male following the operation and retained this character to the termination of the experiment.

4. Well developed spurs were found in all cases. The amount of spur tissue developed does not seem to be greater in the bilaterally ovariotomized fowl than in those sinistrally ovariotomized.

5. The behavior of these individuals is neither male nor female but neutral. Comparable in this respect to that of the capon.

6. The Wolffian ducts hypertrophy following sinistral ovariotomy. No such hypertrophy is perceptible in the bilaterally ovariotomized fowl, these ducts being small, straight and often very difficult to find.

7. The amount of oviduct tissue varies greatly in the sinistrally ovariotomized fowl. In the cases of complete bilateral ovariotomy here recorded the oviduct is reduced to a very small straight flattened tube, 2–3 mm. in diameter. Very small rudiments of the right oviduct were found in all cases.

8. No changes were observed in size. The birds retained approximately the size of normal hens.

Explanation of Table on Bilateral Ovariotomies.

The table includes cases of complete as well as incomplete bilateral ovariotomy. The complete cases are those in which no gonad regenerated on either right or left sides as determined by post-mortem examination. In incomplete cases masses of gonad varying in size are found on either right or left sides or both. On account of the length of the records each case is continued on a second page.

The record of each case consists of selections, from very much more complete records, considered to be most important for the operation history. In some cases other data are recorded in the text. The preserved records consist of notebooks containing complete histories of all birds, photographs, feather records for each case, skins, preserved Sacrums with the urinogenital organs in situ for each case, and other anatomical preparations. All enteries have been checked thrice from the original records.

Column 1 gives the identification number of each bird.

Column 2 gives the age of the bird in days at the time of the first sinistral operation. It also gives the dates of the sinistral and dextral operations in their order. The sinistral operation always preceded.

Column 3 gives the date of death and autopsy and, if the bird was found dead, this fact and the cause of the death, if known. Cb. signifies crop-binding revealed at post-mortem.

†. A "secondary operation" for removal of regenerated gonad.

"Successive changes in plumage" and "successive changes in head furnishings" are recorded at 3 months, 6, 12, 18, 24, and 30 months following

the date of the operation. These periods are not always the best for recording changes, hence observations at other times are frequently entered in the nearest column and indicated by a number in parenthesis giving the actual age in months above the individual entry. All such dates are approximate only, but on account of the relative slowness of the changes they are sufficiently exact.

Plumage Changes.—The changes recorded are, in general, the natural plumage changes, not forced by plucking. The only exceptions are operation sites though, because of the rapid continuous development of male plumage in most of these cases, these are not long apparent.

♂ indicates feathers of cock or capon type not distinguished.

♀ indicates feathers of female type.

"Tipped" always refers to feathers with female tip and male base which appear shortly after ovariotomy; these feathers have commonly a very sharp line of demarcation between the components, and are frequently referred to as "gynandromorph" feathers in the literature. Such feathers may begin to appear in 10 to 14 days after a successful operation, and they are commonly abundant at 3 months interspersed with new completely male feathers. I. signifies "intermediate," and represents the beginning of the secondary transformation from the male to the female type of feathers in these birds. These feathers may have male tips and female bases, but the transition zone is not sharp but diffuse. In some instances the entire feather is intermediate or of this diffuse nature.

Where regions are indicated, abbreviations are used Br. for breast, Ba. for back, Sa. for saddle, T. for tail, W's. for wings, Wc's. for wing coverts, Juv. for juvenile, etc.

Head Furnishings (measurements are in centimeters).—The comb is given first, the length of the main blade of the comb from front to back being the numerator and the greatest depth from the highest point to the base the denominator; the wattles come second, width over depth; the vertical diameter of the ear-lobe comes last.

Spurs.—Spurs are recorded by their length in centimeters at date of autopsy.

Findings at Autopsy.—At the time of autopsy, the head was preserved separately in formalin, the skin with, or without, legs attached removed, cured and preserved, and the entire sacrum with urinogenital organs including gonads, if present, fixed in Bouin's fluid.

Right and Left Gonads.—None signifies no gonad, T. signifies "testis-like" gonad macroscopically, † see column 3. Measurements are length over transverse diameter, in centimeters. These 'regenerated' gonads are less irregular than the normals frequently are hence the measurements are fairly good comparative estimates of volume in these cases.

Right and Left V. D. (vas deferens).—For purposes of succinct characterization the arbitrary scale previously devised (Domm, *'27a*) was utilized in which 1 corresponds to the condition of the normal right vas deferens in the female and 5 that of the male; 2, 3, and 4 represent intermediate conditions; 2, wide, straight; 3, slightly convoluted; 4, strongly convoluted. Observations are more difficult to make on the left side on account of accumulations of fat in the mesentery of the oviduct where the

vas lies; a question mark in this column indicates only that the observation could not be made owing to fat (*e.g.*, 875, 882, 884, etc.).

Oviduct.—Similarly, a scale of 6 points was adopted for recording variations of the left oviduct. 1, the most reduced type, straight and only 2–3 mm. in diameter; 2, straight, 4 mm. or more in diameter; 3, convoluted, 3–5 mm. in diameter; 4, convoluted, 6–9 mm. in diameter; 5, convoluted, 10 + mm. in greatest diameter; 6, oviduct of a normal laying hen (see Domm, '27*a*, compare plate 8, Fig. 2*b*; plate 9 and 10; also plate 11, no. 729). * Varying portions of oviduct inflated with fluid (see text page 19).

SUMMARY OF BILATERAL OVARIOTOMIES.

Bird No.	Operation age and Date.	Autopsy Date.	Successive Changes in Plumage.						Spurs.	
			3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt.	Lt.
874	76 d. 9–14–26 9–30–26	Died 4–16–28	Predom.♂,some Juv. Some old ♀ and ♀ Tp'd. New♂.	♂ in all areas. New ♂.	♂ in all areas New♂.	♂ in all areas. New♂.	(19) ♂ in all areas. New♂.		2.0	1.9
875	76 d. 9–14–26 9–30–26	Died 10–11–28	Predom.♂. Many Juv. Some old ♀ and ♀ Tp'd. New♂	♂in all areas, few scat. old ♀ WC's. New ♂.	♂in all areas. New♂.	♂in all areas. New♂.	(25) ♂in all areas. New♂.		1.8	1.9
876	76 d. 9–14–26 9–30–26	Died 11–11–28	Predom.♂. Many Juv. prin. on Ba. and Sa. Some old ♀ and ♀ Tp'd. New♂.	♂in all areas. Some Juv. on Ba. and Sa. few scat. old ♀ WC's. New♂.	♂in all areas. New♂ numerous. Molting.	♂ in all areas. New♂.	(26) ♂ in all areas. New♂.		2.3	2.3
878	76 d. 9–14–26 9–30–26	Died 7–20–27	Predom.♂,few Juv. on Ba. Sa. and W'S. few old ♀ and ♀ Tp'd. New♂.	♂in all areas. New♂.	(10) ♂in all areas. New♂.				1.7	1.7
880	76 d. 9–14–26 9–30–26	11–2–27	Predom.♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New♂.	♂in all areas. Some old ♀. few I. New ♀.	(8) Predom.♂. ♀ bec. numerous. few I. New ♀.	(12) Predom.♂. many ♀. few I. New♂.	(13½) Predom.♂.few Scat. ♀ and I. New♂.		0.5	1.1

Bird No.	Successive Changes in Head Furnishings.							Findings at Autopsy.				
	At Operation.	3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt. Gonad.	Lt. Gonad	Rt. V.D.	Lt. V.D.	Lt. Ovd.
874	2.1 1.0 — — 1.1 0.6 0.4	2.6 1.6 — — 1.4 1.4 0.6	3.6 2.0 — — 1.6 2.1 1.1	5.2 2.4 — — 1.6 2.5 1.9	5.2 2.2 — — 1.7 1.9 1.7	(19) 4.8 1.9 — — 1.6 1.7 1.3		None	T. 1.5 — 0.5	1–2	1–2	1
875	1.0 1.3 — — 1.1 0.5 0.3	2.5 1.6 — — 1.4 1.1 0.6	2.8 1.5 — — 1.5 1.4 0.5	3.0 1.9 — — 1.5 1.4 0.9	3.0 2.0 — — 1.5 1.3 1.0	(25) 2.8 2.0 — — 1.4 1.1 1.0		None	None	1	?	1
876	2.1 1.5 — — 1.1 0.6 0.4	2.9 1.9 — — 1.2 1.4 0.6	2.7 1.5 — — 1.3 1.4 0.5	4.3 1.7 — — 1.5 1.6 1.3	4.3 1.9 — — 1.5 1.6 1.3	(26) 4.1 2.1 — — 1.4 1.4 1.1			None	1	1	1
878	2.1 1.3 — — 1.0 0.7 0.4	2.6 1.5 — — 1.5 1.4 0.6	3.7 2.0 — — 1.6 2.3 1.2	(8) 4.5 2.1 — — 1.8 2.8 1.5	(10) 4.2 1.9 — — 1.6 2.4 1.0			None	T. 1.1 — 0.3	1	1	1 *
880	2.1 1.3 — — 1.1 0.0 0.1	2.8 1.5 — — 1.6 1.1 0.6	6.9 3.3 — — 2.4 3.9 3.0	(8) 8.9 3.9 — — 2.8 5.1 4.1	(12) 6.8 2.6 — — 2.5 3.9 3.0	(13½) 5.7 2.1 — — 2.3 2.6 2.3		None	T. 1.2 — 0.3	2	2	1

Bird No.	Operation age and Date.	Autopsy Date.	Successive Changes in Plumage.						Spurs.	
			3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt.	Lt.
882	78 d. 9–16–26 9–30–26	3–2–29	Predom.♂. Many Juv. on Ba. and Sa. few on W'S. Some old ♀ and ♀ Tp'd. New♂.	♂in all areas. Some Juv. on Ba. and Sa. New♂.	♂in all areas. New♂.	♂in all areas. New♂.	(25) ♂in all areas. New♂.	(29½) ♂in all areas. New♂.	2.0	1.4
884	78 d. 9–16–26 10–6–26	2–8–29	Predom.♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New ♂.	♂in all areas. few Juv. few old ♀ on W'S. New♂.	♂in all areas. New♂.	♂in all areas. New♂.	(25) ♂ in all areas. New♂.	(28¾) ♂in all areas. New♂.	3.0	3.3
887	78 d. 9–16–26 10–5–26	3–1–29	Predom.♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New ♂.	♂in all areas. few old ♀ on W'S. New ♀.	♂in all areas. New♂.	♂in all areas. New♂.	(25) ♂in all areas. New♂.	(29½) ♂in all areas. New♂.	1.0	1.5
888	78 d. 9–16–26 10–5–26	Died 12–6–26	(2¾) Predom.♂. Many Juv. on Ba. Sa. and W'S. Some old ♀. New♂.						0.2	0.2

Bird No.	Successive Changes in Head Furnishings.							Findings at Autopsy.				
	At Operation.	3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt. Gonad.	Lt. Gonad.	Rt. V.D.	Lt. V.D.	Lt. Ovd.
882	2.2 1.0 — — 1.2 0.9 0.7	2.9 1.6 — — 1.2 1.4 0.7	2.9 1.7 — — 1.6 1.5 0.7	3.1 1.8 — — 1.8 1.4 0.8	2.9 1.9 — — 1.7 1.3 0.8	(25) 3.0 1.9 — — 2.0 1.3 1.0	(29½) 2.9 1.8 — — 1.7 1.2 1.0	None	None	1	?	1
884	2.0 1.4 — — 0.8 0.7 0.3	2.5 1.5 — — 1.4 1.0 0.5	2.7 1.4 — — 1.2 1.1 0.4	2.7 1.4 — — 1.3 1.1 0.4	2.9 1.4 — — 1.6 1.1 0.7	(25) 2.8 1.5 — — 1.4 1.0 0.6	(28¾) 2.8 1.5 — — 1.4 0.9 0.5	None	None	1	?	1 *
887	1.8 1.2 — — 0.9 0.7 0.3	2.5 1.6 — — 1.2 1.4 0.6	4.6 2.0 — — 1.5 2.5 1.3	4.0 1.7 — — 1.5 2.1 0.9	4.1 1.8 — — 1.4 1.6 1.0	(25) 4.1 1.9 — — 1.5 1.7 1.1	(29½) 4.1 1.7 — — 1.6 1.6 1.1	None	None	1	?	1 *
888	2.0 1.4 — — 0.8 0.8 0.3	(2¾) 2.9 1.8 — — 1.1 1.1 0.4						None	None	1	?	1

Bird No.	Operation Age and Date.	Autopsy Date.	Successive Changes in Plumage.						Spurs.	
			3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt.	Lt.
890	78 d. 9–16–26 10–5–26	8–12–27	Predom. ♂. few Juv. on Ba. and W'S. Many old ♀. Some ♀ Tp'd. New ♂.	Predom. ♀. Many scat. ♂. Some I. New ♀.	(8) Predom. ♀. Many Scat. ♂. Some I. New ♀.	(11) aprox. ½♂ ½ ♀. Some I. New Ba. ♂.			0.3	0.3
891	78 d. 9–16–26 10–5–26	3–1–29 †	Pract. all ♂. Many Juv. few scat. old ♀ and ♀ Tp'd. New ♂.	Predom. ♂. Many new ♀. Some I. New ♀.	Aprox. ½♂ ½ ♀. New ♂.	♂ in all areas. New ♂.	(25) ♂ in all areas. New ♂.	(29½) ♂ in all areas. New ♂.	2.7	2.7
893	79 d. 9–17–26 10–5–26	7–23–27	Predom. ♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New ♂.	Predom. ♂. Some I and new ♀. New ♀.	(10¼) Predom. ♂. Many ♀. Some I. New ♀.				1.3	1.3
894	79 d. 9–17–26 10–6–26	5–6–29	Pract. all ♂. Some Juv. on Ba. Sa. and W'S. few old ♀ and ♀ Tp'd. New ♂.	♂ in all areas. Some Juv. on Ba. and Sa. New ♂.	♂ in all areas. New ♂.	♂ in all areas. New ♂.	(25) Predom. ♂. Many ♀. few I. New ♀.	(31½) Predom. ♀ in all areas, few scat. ♂ and I. New ♀.	4.4	Lost

Bird No.	Successive Changes in Head Furnishings.							Findings at Autopsy.				
	At Operation.	3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt. Gonad.	Lt. Gonad.	Rt. V.D.	Lt. V.D.	Lt. Ovd.
890	2.1 1.3 —— 1.0 0.8 0.3	2.6 1.4 —— 1.3 1.2 0.3	7.4 3.2 —— 2.2 3.6 3.1	(8) 9.4 4.0 —— 2.6 4.3 4.2	(11) 6.8 2.6 —— 2.1 2.8 2.8			None (See text p. 8)	None	1	1	3
891	2.3 1.4 —— 1.0 1.0 0.3	3.1 1.7 —— 1.2 1.7 0.5	(7) 9.5 3.7 —— 2.4 5.4 3.6	5.1 2.4 —— 2.2 2.6 2.2	4.8 2.2 —— 2.0 2.3 1.6	(25) 4.6 2.3 —— 2.0 2.2 1.8	(29½) 4.5 2.2 —— 1.8 2.2 1.8	† 10–16–27 T. Small Cauterized. . . . . . 3–1–29 None	None	1	?	1
893	2.2 1.3 —— 1.0 1.1 0.3	2.7 1.6 —— 1.4 1.6 0.6	7.7 3.5 —— 2.1 5.1 3.4	(8) 9.3 4.3 —— 2.6 6.1 4.8	(10¼) 5.4 2.3 —— 1.8 2.9 2.2			T. 0.6 —— 0.3	T. 0.8 —— 0.2	1	1	3
894	1.8 1.4 —— 0.8 0.5 0.3	2.6 1.8 —— 1.3 1.2 0.4	3.0 1.6 —— 1.3 1.4 0.4	3.6 1.7 —— 1.6 1.4 1.0	5.7 2.3 —— 1.9 2.5 1.8	(25) 9.0 3.3 —— 2.2 4.3 3.2	(31½) 10.8 3.8 —— 2.3 5.9 3.8	T. 1.5 —— 1.1	T. 0.9 —— 0.9	3	3	4

Bird No.	Operation age and Date.	Autopsy Date.	Successive Changes in Plumage.						Spurs.	
			3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt.	Lt.
895	79 d. 9–17–26 10–6–26	3–1–29	Pract. all ♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New ♂.	♂ in all areas. Some Juv. on Ba. and Sa. New ♂.	♂ in all areas. New ♂.	♂ in all areas. New ♂.	(25) ♂ in all areas. New ♂.	(29½) ♂ in all areas. New ♂.	3.0	3.0
897	79 d. 9–17–26 10–5–26	9–29–27	Pract. all ♂. Many Juv. on Ba. and Sa. few on W'S. Some old ♀ WC'S. New ♂.	♂ in all areas. exc. few old ♀ WC'S. New ♂.	(12½) ♂ in all areas. New ♂.				1.4	1.2
898	79 d. 9–17–26 10–5–26	Died 6–7–27 Cb.	Pract. all ♂. Many Juv. on Ba. and Sa. few on W'S. few old ♀ and ♀ Tp'd. New ♂.	♂ in all areas. exc. few old ♀ Tp'd. WC'S. New ♂.	(8½) ♂ in all areas. New ♂.				1.6	1.6
899	79 d. 9–17–26 10–6–26	2–24–27	Pract. all ♂. Many Juv. on Ba. Sa. and W'S, few old ♀ and ♀ Tp'd. New ♂.	(5¼) ♂ in all areas. Many Juv. few old ♀ WC'S. New ♂.					0.6	0.6

Bird No.	Successive Changes in Head Furnishings.							Findings at Autopsy.				
	At Operation.	3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt. Gonad.	Lt. Gonad.	Rt. V.D.	Lt. V.D.	Lt. Ovd.
895	2.0 1.4 — — — 1.0 0.7 0.3	2.6 1.6 — — 1.4 1.4 0.6	3.1 2.0 — — 1.5 1.6 0.5	3.3 2.0 — — 1.6 1.5 0.8	3.4 2.0 — — 1.7 1.3 1.0	(25) 3.5 2.0 — — 2.1 1.3 1.2	(29½) 3.5 2.0 — — 2.0 1.3 1.1	None	None	1	1	1
897	2.1 1.2 — — 0.8 0.9 0.4	2.8 1.4 — — 1.2 1.2 0.6	3.2 1.6 — — 1.2 1.5 0.7	(9) 3.2 1.6 — — 1.3 1.6 1.0	(12½) 3.2 1.6 — — 1.3 1.7 0.8			None	None	1	1	1
898	1.9 1.2 — — 0.9 0.7 0.3	2.6 1.6 — — 1.3 1.3 0.7	8.1 2.4 — — 1.7 3.2 1.8	(8½) 5.2 2.1 — — 1.4 2.4 1.4				T. 0.3 — 0.2	T. 1.0 — 0.2 +	3	3	1
899	2.0 1.1 — — 0.9 0.9 0.2	2.7 1.4 — — 1.3 1.1 0.3	(5¼) 2.5 1.2 — — 1.2 1.2 0.2					None	None	1	1	1 *

Bird No.	Operation age and Date.	Autopsy Date.	Successive Changes in Plumage.						Spurs.	
			3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt.	Lt.
902	79 d. 9–17–26 10–5–26	Died 7–4–27	Predom. ♂. Many Juv. on Ba. and Sa. few on W'S. Some old ♀ and ♀ Tp'd. New ♂.	Predom. ♂. few Juv. few old ♀ WC'S. New ♂.	(9½) ♂ in all areas. New ♂.				0.5	0.5
903	79 d. 9–17–26 10–6–26	6–3–27	Predom. ♂. Many Juv. on Ba. and Sa. few on W'S. Some old ♀ and ♀ Tp'd. New ♂.	Predom. ♂. Some Juv. on Ba. Sa. and W'S. few old ♀ WC'S. New ♂.	(8½) ♂ in all areas. Some Juv. on Sa. and W'S. New ♂.				1.1	1.1

Bird No.	Successive Changes in Head Furnishings.							Findings at Autopsy.				
	At Operation.	3 months.	6 months.	12 months.	18 months.	24 months.	30 months.	Rt. Gonad.	Lt. Gonad.	Rt. V.D.	Lt. V.D.	Lt. Ovd.
902	1.9 1.2 —— 1.1 0.7 0.3	2.5 1.7 —— 1.4 1.2 0.3	2.8 1.4 —— 1.6 1.7 0.3	(9½) 2.9 1.6 —— 1.5 1.7 0.3				None	None	1	1	1 *
903	2.0 1.1 —— 1.1 0.8 0.2	2.4 1.3 —— 1.3 1.1 0.3	2.7 1.4 —— 1.3 1.2 0.3	(8½) 2.8 1.4 —— 1.3 1.3 0.3				None	None	1	1	1

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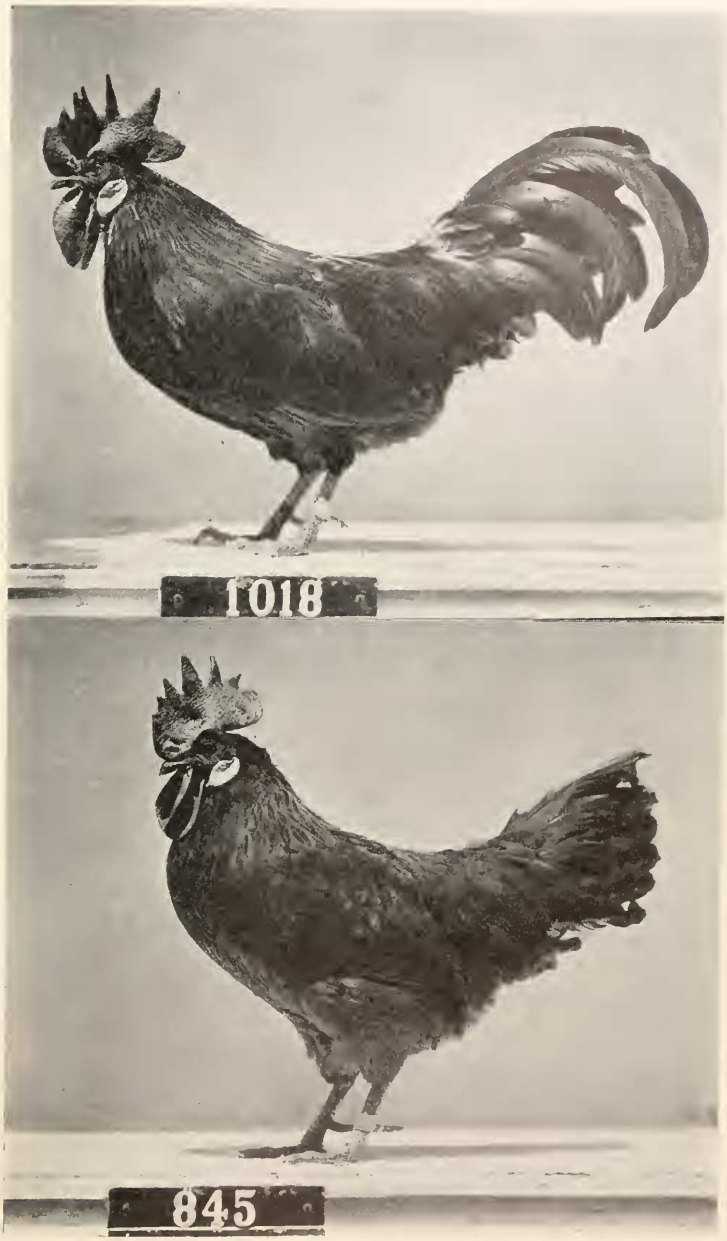
Plate I.

Explanation of Figures.

No. 1018. Poulard *Sinistrally ovariotomized.* This bird was hatched on May 9, 1927, and sinistrally ovariotomized on May 22, 1927, when 13 days old. This photograph was taken on May 22, 1929, 2 years following the operation. The bird at this time was completely male plumaged, showed well developed masculine head furnishings and long spurs. The new ingrowing feathers at this time were intermediate heralding the inevitable change to female plumage which apparently all these birds ultimately undergo.

No. 845. Poulard *Sinistrally ovariotomized.* This bird was hatched on June 16, 1926 and sinistrally ovariotomized on August 11, 1926, when 56 days old. This photograph was taken on May 22, 1929, approximately two years and nine months following the operation. The bird at this time was completely female plumaged though it showed prominent masculine head furnishings, spurs, and behavior. The definitive condition thus is one in which the sinistrally ovariotomized fowl becomes female plumaged while she retains her other acquired male characters. Complete dextral ovariotomy in such a bird brings about the reassumption of male plumage and a loss of the dependent sexual characters leading to the asexual capon type (see Domm, '27*a*). (Compare bird no. 876, Plate 2.)



L. V. DOMM.